A STRATEGY FOR THE EVALUATION OF KINETIC TEMPERATURE T_k PROFILES FROM SABER

A first concern for the SABER measurements and retrievals is the accuracy for the pressure registration of its radiance profiles. That quality can be checked most easily and quickly by comparing its daily zonal mean T(p) versus latitude with that from the NCEP stratospheric analyses obtained with the AMSU sounder measurements of the NOAA operational satellites.

A more difficult challenge is to verify that the kinetic temperatures T_k derived with the SABER algorithm of Mertens et al. [GRL, April 1, 2001, p. 1391] are accurate for the mesosphere and lower thermosphere. Mertens et al. [2001] indicate that kinetic temperature can be retrieved to an accuracy of about 3K with a vertical resolution of nearly 2 km. Temperature profiles exhibit a lot of structure in that region of the atmosphere due to tides and gravity waves, such that excellent spatial and temporal coincidence for individual pairings with correlative measurements is nearly impossible. This problem can be avoided to first order by conducting comparisons for those latitudes and months (April through September for NH) when the middle atmospheric winds are easterly, inhibiting the vertical propagation of planetary and orographically-induced gravity waves. This approach was employed effectively by Remsberg [GRL, p. 311, 1986] for a validation of LIMS T(p) profiles with the 4-year monthly averages of the temperature values from the ground-based Rayleigh backscatter lidar at Observatorie Haute-Provence (OHP) in southern France. Later, Remsberg et al. [2001] developed sets of individual paired-profile comparisons with the HALOE T(p) values near the OHP site. They found excellent agreement from 35 to 80 km for a set of profile-pairs during May through August of the middle 1990s.

The relatively-local, correlative lidar and incoherent scatter radar (ISR) measurements are obtained by averaging returns over minutes to hours. On the other hand, the limb-viewing SABER profile measurement represents a horizontal path-averaged result over nearly 300 km within about 30 seconds of time. SABER obtains its next profile about 200 km further along in its orbit, so there will be opportunities to compare the ground-based measurements with more than one orbital SABER profile. For these reasons it is expected that the more random, small-scale geophysical variations of temperature will be averaged for both the SABER and the correlative datasets.

Because the OHP facility is part of the Network for Detection of Stratospheric Change (NDSC), it should be possible to obtain their routinely-measured profiles without too much delay. Even so, there will likely not be excellent agreement near the mesopause and above, because of the background subtraction and initial profile uncertainties for the lidar retrievals. Comparisons with inflatable falling sphere profiles will be helpful for validating SABER temperatures to near the mesopause, if the spheres are released from the rockets at their nominal 90-km altitude level. We also seek any Rayleigh lidar data from the Kuelingsborn, Table Mountain, Mauna Loa, and Reunion Island sites, as well as from the NSF CEDAR Class-I facilities.

Resonance lidar determinations of temperature (by Colorado State and the U. of Illinois) will be very useful in the 80 to 100 km region, where it is expected that the mixing ratio of CO2 will be decreasing upward from its assumed constant value in the lower atmosphere and where some of the CO2 emissions measured by SABER will be from vibrationally-excited levels of that molecule and its other isotopes. Temperatures from the OH rotational emission measurements will also be helpful. The incoherent scatter radar (ISR) measurements from Millstone Hill and other sites will be invaluable for altitudes above 100 km. Both day and night comparisons are needed in order to check the SABER NLTE algorithm. The SABER operations team will provide a prediction of the orbital overpass times for a given site, based on the expected launch date and orbital parameters for TIMED. It will be important to obtain several days of correlative temperatures early in the TIMED mission (in September 2001, if launch is August 10).

Alternatively, if the TIMED satellite is launched after the NH summer, it is reasonable to expect good comparisons between SABER and HALOE daily zonal mean T(p) values at those SH latitudes where there are middle atmospheric easterlies. In the event that HALOE is not operating at that time, one can still compare with the climatological temperatures from HALOE at those latitudes and months. Comparisons with the lidar profiles from Antarctica will be valuable, especially during SH summer.

Chris Mertens has shown that the effect of NLTE on the SABER CO2N channel radiances will be greatest for the polar summer mesosphere, when variability is reduced. These conditions should make it easier to obtain representative correlative measurements for comparison, perhaps from Kiruna and Andenes. Therefore, it is recommended that the summer hemisphere (away from PMCs) be the focus of a ground-based campaign to evaluate the accuracy of the NLTE model for SABER CO2 radiances and its retrieved kinetic temperature. An advantage at higher latitudes is that successive orbits of the SABER data will be separated by a much smaller physical distance than will be the case at low latitudes. For this reason even if excellent coincidence is not attained for a given orbit, one can also conduct comparisons with SABER profiles from adjacent orbits taken within several hours. It is expected that SABER will have a nearly 100% duty cycle (be observing each day), such that SABER measurements will be obtained near a given high latitude site twice a day, and the two local times for the SABER tangent points will precess slowly during the half-yaw (60 day) cycle when it is viewing toward one Pole.

Papers in review and preprints available upon request:

Bhatt, P. P., E. E. Remsberg, and L. E. Deaver, Seasonal and longer-period cycles in middle atmosphere temperature at 40N from UARS HALOE, in review at JGR, 2001.

Remsberg, E. E., G. Lingenfelser, P. Bhatt, L. Deaver, J. Wells, J. M. Russell III, L. Gordley, R. Thompson, M. McHugh, P. Keckhut, and F. Schmidlin, The validation of HALOE temperature profiles in the mesosphere using Rayleigh backscatter lidar and inflatable falling sphere measurements, in review at JGR, 2001.

2.5 SABER Level 3 Map and Cross Section Data

A Level 3 map product will be prepared using the Fast Fourier Synoptic Mapping (FFSM) technique of Salby [JAS, p. 2601, 1982], as outlined at a previous SABER Science Team Meeting by Rolando Garcia. This asynoptic sampling technique has the advantage that, where sampling frequency is adequate, alias-free, synoptic maps can be constructed from asynoptic observations. Further details of the methodology as applied to UARS data can be found in Sassi and Salby [JGR, p. 10,885, 1998].

An alternate method for generating maps for validation purposes employs the Kalman filter algorithm that was used to obtain the Fourier coefficient form of the LIMS dataset [Remsberg et al., J. Atmos. Oceanic Tech., p. 689, 1990]. It provides an interpolation in time across the gaps in the LIMS dataset. That code will be exercised prior to launch by running it with the LIMS V6 Level 2 product, whose profile points have already been screened of clouds and interpolated onto a pressure-altitude grid. (It is assumed that this will be the form of the Level 2 SABER data.) Those Level 2 profiles must then be sorted into time series at specific latitudes, prior to being used as input to the mapping algorithm. Estimates of the data precision for each parameter will determine how closely to fit the points of each time series. The Kalman filter output file contains 13 zonal Fourier coefficients for each day, latitude, and pressure-altitude at 12Z. Remsberg et al. [J. Geophys. Res., p. 23,001, 1994] have shown that it is easy to obtain coincidences with correlative temperature profiles by reconstructing a SABER profile at a station location from this map product. Zonal-mean profiles can also be reconstructed from auxiliary satellite data sets, such as HALOE or NCEP/UKMO. Zonal-mean or orbital cross section plots can be generated from those auxiliary datasets and compared. Similar approaches will be used for the initial comparison of ozone, water vapor and nitric oxide from SABER and HALOE. The HALOE profile data and images can be viewed at http://haloedata.larc.nasa.gov/home.html.

The LIMS Version (V6) Level 2 profile data can be viewed at the LIMS Website http://lims.gats-inc.com.
A draft manuscript describing the LIMS V6 data set will also be accessible soon through that Website. The LIMS V6 data have been certified for 3 test days—022, 125, and 312. Processing for the month of January 1979 should be complete at the time of SABER launch.

It should be noted that, regardless of the method used for mapping SABER data, there is a possibility of severe aliasing in the upper mesosphere. Since SABER will at best sample the atmosphere twice daily, it follows that any variability occurring on scales faster than one day will be aliased in the mapped products. In those regions where aliasing is a problem, compositing methods may be used to obtain at least a "time-average" view of rapidly varying fields. A procedure for obtaining composite maps using data taken over the TIMED precession cycle is outlined in a proposal by Sassi, Garcia, and Salby.

2.6 SABER Channel Validation Sequence

Certain internal consistency studies will be preformed on the initial Level 2 data set. First, adjacent profiles along an orbit track across the summer hemisphere stratosphere should show little variation due to the weak planetary wave and reduced gravity wave activity of that atmospheric domain. In fact, the standard deviation of a set of those adjacent profiles about their mean value should be a good upper limit measure of the profile precision. Ascending/descending zonal mean differences should be near zero or have very small systematic differences for T, ozone, and water vapor in the stratosphere. Any systematic differences ought to have a pattern that is coherent with latitude and pressure, if they are due to tidal motions. Such plots will be a critical first-order diagnostic of any residual effects of uncertainties in spacecraft attitude and of the instrument FOV and electronics functions. They were very important in unraveling the subtle attitude effects that were leading to hemispheric asymmetries in the species distributions of the archived LIMS Version (V5) dataset. Once the registration of the radiance profiles has been shown to be correct, one can immediately begin to analyze the SABER radiance data for the expected contributions of the primary molecules (CO2, ozone, NO, and water vapor) to a radiative energy balance model of the mesosphere and lower thermosphere.

After these simple tests are successful one can then proceed with a validation of the absolute value of each parameter profile. Because accurate temperatures are so critical for a useful retrieval of the species profiles of a limb emission measurement, it is important to determine the quality of those temperature values. SABER comparisons with the NOAA CPC (or the UKMO) analyses are appropriate for the upper stratosphere and comparisons with UARS HALOE for the upper stratosphere and mesosphere. In fact, Bhatt et al. [2001] generated an 8.5-year temperature climatology for 40N from the HALOE data set of the 1990s. Remsberg et al. [2001] compared HALOE temperature profiles in the mesosphere with those from ground-based Rayleigh lidar and inflatable falling sphere measurements. Their comparison approaches provide useful analogies for intercomparisons of correlative measurements with the SABER profiles of kinetic temperature.

Initially, the distributions of ozone, water vapor, and nitric oxide will be compared with the global UARS reference climatology and with the high latitude profiles from the POAM II and III datasets. Comparisons will also be made with the species distributions from the SAGE and operational SBUV/2 series of satellite instruments. Profiles of the hydroxyl (OH) radical will be compared with those from the Shuttle-borne MAHRSI experiment for the upper mesosphere. Emission profiles from O2 (1D) will be compared with those from the reprocessed SME dataset and from the rocket experiment METEORS. Finally, the emission measurements from the 4.3-micrometer CO2 channel will be evaluated against the spectral emission profiles of this feature obtained from previous rocket and satellite experiments, as provided by AFRL.